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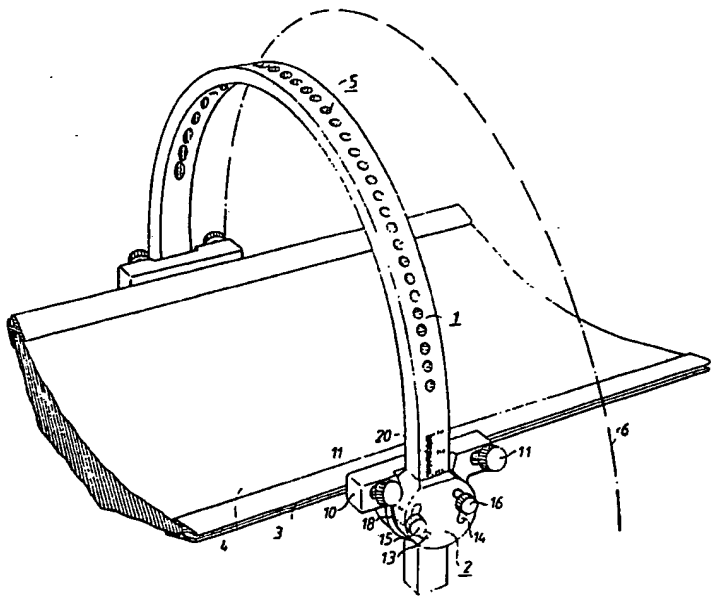
(54) Title: BIOPSY ARC MEANS AND THE USE OF THE SAME

(57) Abstract

The invention relates to a biopsy arc (1) intended to be the support of examination means in the form of needles (23), in connection with so called computed tomographic examination. The inventive novelty resides in the feature that the arc is removably secured to the patient's table (4) or a corresponding base member and angularly adjustable in order to be adapted to the direction of the respective section image plane. The biopsy arc is provided with a plurality of apertures (5) directed towards the area enclosed by the arc for guiding the respective examination means. The arc is made of a material which has an attenuation with respect to X-ray radiation which lies at or below the value exhibited by organic tissue. Hereby the arc as well as organs can be brought to appear and stand out together on the section picture (Fig. 5, 6) in order that a suitable aperture and direction of examination be selected with no risk of disturbing artefacts.



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BIOPSY ARC MEANS AND THE USE OF THE SAME.

Technical field

In connection with computed tomographic examinations nowadays often so called biopsy arcs are used, that is, guiding instruments for inserting properly and safely examination means, such as sampling needles and the like, into the patient body concerned. Usually such biopsy arcs are provided with complicated adjustment means for directing the needles, and they require that the operating personnel be thoroughly trained in order that said means be used in an appropriate manner. Furthermore there are very often a risk of so called disturbing artefacts caused by the structure of the devices when these come into the vicinity of the section image. In examinations of the said kind it is thus very important that the occurring section images of the patient body concerned are not disturbed by structural material attenuating the radiation, as the contents of the images can easily be misinterpreted in such cases.

Prior art

In this technical field there are a plurality of known designs, as can be seen from the patent literature. As an example the German Publication DE 32 05 915 can be mentioned. The device shown in this paper includes an arc which encloses substantially 270° of a circle and is secured to a patient's table. On the arc, which is provided with indicia, there is a slider to be slidably pushed along the arc. The slider includes a needle carrier which is movable about an axis and thus able to be turned in the plane of the arc. After a section image of a body under examination has been studied and the organ to be examined or punctured has been localized, the approximate insert angle of the needle is determined, also the depth of insertion, after which the needle carrier is set on the arc in the estimated position and approximately directed. Then the needle is inserted into the patient and loosened from the arc in order that a check picture be taken and the needle position obtained evaluated. Should positioning not be carried out exactly as intended the needle has to be pulled out, a new directing operation be carried out and the needle be inserted again. This is of course not satisfactory neither with respect to the examination nor to the patient.

The German Patent Specification DE 33 39 259 discloses an arc

arrangement provided with some radial apertures through which guide means can be inserted for, in this case, drilling. The arrangement has no direct bearing on computed tomography but still it is mentioned as representing prior art guiding instruments.

As an example of usually occurring biopsy arc arrangements reference is made to the USA Patent Specifications Nos. 4 350 159 and 4 463 758. These arrangements both include advanced structures for adjusting needles when carrying out examinations of the said type in connection with computed tomography. As can be clearly seen from the structure of these arrangements very disturbing artefacts can arise in the tomographic pictures if parts of the structures concerned should enter into the respective section picture.

Thus there is a need of a simple and safe method of determining the position as well as the penetration depth of an examination needle without it being necessary to resort to either intricate trigonometric calculations or complicated apparatus adjustments.

Summary of the invention

The present invention solves the problem mentioned above in a very simple and appropriate manner. A biopsy arc according to the invention, in particular for computed tomography, is provided with a plurality of apertures directed towards the area within the arc, the arc being mounted in such a way that it can be angularly set for adjustment of the plane of the arc to a plane of image section in the computed tomographic apparatus. Furthermore, the arc should be such as to exhibit such an attenuation of the radiation concerned which is equal to or less than that exhibited by organic issue. The arc will then form part of the related section image, whereby the directions of the apertures will be identifiable. Hereby it is possible, in order to select a suitable path for inserting an examination means, to select a suitably directed aperture through which said means can be inserted. Expediently the apertures have such a diameter that they can receive guiding sleeves for the examination means concerned, such as a needle or the like. Thanks to the fact that the arc has apertures of a comparatively large size these apertures will be clearly depicted in the section image as channels of given directions. Hence, it is comparatively simple to select an aperture for inserting an examination means if, in the image, the direction of the aperture agrees with the desired path of insertion.

Contrary to what is occurring in known techniques the biopsy arc is allowed to remain in the path of the X-ray beam creating the image section, in order to render it possible to utilize the arc configuration in the section image in connection with the examination contemplated.

The characterizing features of the present invention appear from the patent claims following the specification.

The invention will be described in greater detail with reference to the accompanying drawings which illustrate embodiments of the invention.

In the drawings

Fig. 1 shows a biopsy arc in accordance with the invention in perspective and mounted on a patient base.

Fig. 2 shows said arc partly in section.

Fig. 3 shows a lateral view of the arc.

Fig. 4 shows a guiding sleeve and an examination needle inserted in the same.

Fig. 5 shows a tomographic section picture with the biopsy arc outlined therein.

Fig. 6 shows essentially the same picture as Fig. 5 but with a computer designed reference grid applied.

Fig. 7 shows a biopsy arc design with chordally directed apertures only.

Fig. 8 shows a biopsy arc having radially directed apertures only.

Disclosure of embodiments

The biopsy arc 1 shown in Fig. 1 is connected, by a detachable support member 2, with guide rails 3 on either side of a patient's table 4. The biopsy arc is provided with a plurality of apertures 5. Patient's table 4 is insertable in a computed tomography installation 6, in a manner not to be described in detail.

As seen from Fig. 2 there are, on one half of the biopsy arc, a number of radially extending apertures 7 which are directed towards a central target point 8. On the opposite side of the arc 1 there are a number of apertures 9 parallel with each other and chordally directed.

As can be clearly seen in Figs. 2 and 3 the support member 2 of the biopsy arc 1 is provided with a slide 10 intended to run

along the respective side rail 3 and to be locked to the rail in desired positions by means of set screws 11. The biopsy arc 1 itself can be clamped by its legs or shanks against the respective slide 10 by means of a plate 12 having slits 13, 14 through which retaining screws 15, 16 are inserted. By the slit arrangement 13, 14 the biopsy arc 1 can be adjusted in various angular positions in relation to the patient's table 4, as indicated by the double arrow 17. To this end indicia 18 are provided on the side of each plate 12. The disengageable clamping of the biopsy arc shanks by means of the plates 12 and the retaining screws 15, 16 brings with it that a certain adjustment of height can be performed in order to adjust to the body of the patient concerned, as indiacted by the double arrow 19. On the biopsy arc 1 itself indicia 20 are provided on each shank.

To make it possible to guide and secure an examination needle in the desired position in any of the apertures 5 a sleeve 21 having a flange 22 is provided. The sleeve is made with a central through hole, through which a needle 23 can be inserted, as shown in Fig. 4. Suitably a socket 24 is pushed onto the needle, to be secured to the needle by a set screw. Hereby an insertion stop is provided, whose position is adjusted in accord with the required length to which the needle is to be inserted into the patient's body. The device shown in Fig. 4 has the advantage that only the needle 23 and the sleeve 21, 22 need be sterilized between various examinations of a patient, thus not the arc proper.

The biopsy arc 1 is made of a material having a density and properties in relationship to the X-ray radiation concerned which can be ranked in the same category as organic tissue density, that is, the density of tissue occurring in a patient's body. The density of tissue generally lies between 40 and 150 Hounsfield units, abbreviated H-units. To clearify the meaning of H-units the following may be pointed out. As it is not practical to work with μ-values in computed tomographic scanning a new scale of values related to the liniar attenuation cooefficient have been defined by Hounsfield. The unit in this new scale is abbreviated H (meaning Hounsfield).

The scanning device used by Hounsfield operated at 120 kV with an aluminium filter of thickness 4.5 mm and a water container 27 cm

thick. Under these particular conditions it was found that the μ--value of water was 0.19 cm^{-1} (i.e. 0.19 per cm), which is equivalent to the μ-value of water measured by a monocromatic beam of 73 keV. In consequence herewith a Houndsfield unit for a substance 'x' is defined by the following equation

$$H = 1000 \frac{\mu_x - \mu\ H_2O\ (\text{at } 73\ keV)}{\mu\ H_2O\ (\text{at } 73\ keV)}$$

or $H = 5263\ \mu_x - 1000$

It is important to know that the above equation is based on the prerequisite that 10 H-units correspond to a change of 1 % of μx, in relation to the μ-value of water.

From the above formula it can be calculated that H of water is 0 while the value of air is -1000 and that the value of dense bone tissue can raise up to +3095 H. A scanning system can thus handle 4096 different H-values for each image element. H-values of some anatomic substances and synthetic materials are shown in the table below.

Dense bone tissue	up to 3095
Bone	200-1000
Teflon	950
Delrin	365
Bakelite	264
Perspex	125
Lexan	105
Nylon	89
Dense tumour tissue	50-90
Coagulated blood	55-75
Brain tissue (grey)	36-46
Brain tissue (white)	22-32
Blood	12
Water	0
Polystyrene	-28
Fat	-100
Air	-1000

Thus the material density of the biopsy arc must not exeed such values that artefact disturbances can arise in the image concerned. Preferably the material should have a value below 200 H.

Polyamide plastics, having a H-value about 80, is satisfactory for most practical purposes. What is essential is the feature that the arc stands out in the section image so that the respective aperture and its direction can be identified.

Use and function of the arrangement

Examination of a patient while using the biopsy arc according to the invention is conducted in the following way:

In modern computed tomographic installations there are laser light beams for positioning so that the section plane of the scanning unit can be projected on the patient's body, after which pencil markings can be made. The biopsy arc is then secured to the patient's table 4 and angularly adjusted in accordance with the markings drawn so that the plane of the arc will coincide with the plane of the image section of the computed tomograph. When the patient's table 4 is again introduced into the tomograph 6 and the requested section pictures are taken, the arc with its apertured channels will be outlined in each picture together with the organic tissues occurring in the image section, in a way as illustrated in Fig. 5. It is assumed that in Fig. 5 a vertebra 25 with ribs 26 belonging thereto are outlined in the picture. Within the area designated 27 the image of a swollen organ stands out which, for example, is to be punctured. Now, the question is to insert the puncturing needle to this organ in such a way that no adjacent organs are damaged. So in this case one of the apertures 7 is selected which as to its direction seems to be the suitable one for reaching the said organ 27, as indicated by the dashed line.

However, in order to make it possible to determine the path and depth of needle penetration a reference grid 28 having a centre line 29 is applied on the monitor image obtained, as seen in Fig. 6, said centre line passing in this case through the spinal cord portion 30 of the vertebra 25. The reference grid is used to find the point 8 towards which the radially directed channels converge, in doing which there is marked on the centre line 29, which coincides with the radial direction of the central aperture of the arc, the point which forms the target point of all radial apertures 7, that is, point 8 in Fig. 2. Starting from said point lines can then be drawn towards apertures 7 in order to select a suitable path of insertion and the associated needle. This reference grid

is divided into such measuring units that they are directly, or by computer, convertable to the penetration depth of the puncturing needle concerned. In practice it is advisable to design the software of the computer such that measures of the depth of penetration and also of the needle socket length can be readily read by cursor control. As have been previously pointed out in connection with Fig. 4, the length of insertion is set by means of the socket 24 which abuts the flange 22 of the sleeve 21 when the proper length of the needle has been inserted.

Thus when the position of an organ 27 has been established a suitable aperture in the arc is selected in accordance with the above, i.e. an aperture having the correct direction towards the organ. The needle length is adjusted as described, after which the patient's table 4 with the patient is pulled out from the computed tomograph, and with the arc in its set position the aperture 7 concerned is used for inserting of the sleeve 21 and said needle 23. The needle is inserted to the depth aimed at and the patient can now be introduced again with the table 4 into the computed tomograph so that a picture for checking can be taken. It should be noted that it is not necessary to remove the arc when checking the position of the needle, as the arc, the needle, as well as the guide sleeve 21 can be allowed to appear in the section image, and this without any disturbing artefacts arising. The result of the organ puncture can also be checked in this manner with all settings unchanged.

If, in viewing the section image, it is seen that the radial apertures 7 cannot be used for the necessary measure, the biopsy arc can readily be turned by its shanks being pulled out from their engagement with the respective support member 2 and turned 180° so that the chordially directed apertures 9 are now located on the side where the organ 27 is situated. A suitable aperture having the requested position and direction can now be selected for the examination intended. In this case lines parallel with the line 29 of the reference grid 28 will now be essentially parallel with the direction of needle introduction, rendering it easy to read the depth of penetration. As can be seen the use of a biopsy arc according to the invention involves only a small number of manipulation steps and calculations as compared with known designs. Thanks

to the feature that the arc can be allowed to form part of the examination image without creating disturbing obstacles and that it is possible to determine in a simple way from this image apertures and positions for inserting the needle, contribution is given to a perspicuity which is very valuable in the practical work involved in computed tomographic examinations. In view of its simple structure and the perspicuous way the arc is used its handling will be very easy to learn.

In some connections it could be advisable to use arcs which e.g. have cordally directed apertures only. Such a structure is shown in Fig. 7.

Likewise it could be advisable sometimes to use an arc which has throughout radial apertures directed towards a central target point. Such a structure can be seen in Fig. 8.

As a matter of course a plurality of designs can be contemplated within the scope of the invention where, for instance, several different types of apertures 5 can occur. For example, such structures can be conceived wherein differently directed apertures are located adjacent one another or in the interspace between apertures. Thus e.g. every second aperture can be radially directed, such as apertures 7, and every second chordally directed, as apertures 9. In a manner suitable for certain purposes groups of apertures can be distributed along the arc and have various directions. Of course also arrays of apertures adjacent each other can be provided, differently directed. Such solutions can be valuable if it is desirable to select an aperture having a very specific direction, in doing which the biopsy arc can be angularly tilted through the plane of the image section according to arrow 17 in order to determine the desired aperture.

The biopsy arc can also be secured to another base member than the patient's table shown. For example, a separate base slab can be used which can be placed on the patient's table and retained thereon by the patient resting on the slab by his own weight.

Claims

1. A biopsy arc, in particular for so called computed tomography, intended to be mounted archwise above a body to be examined and to be adjustably secured to a base member, characterized in that the arc (1) is provided with a plurality of apertures (5) directed towards the area within the arc, that the arc is secured in such a way that it can be angularly adjusted (17) in order to adapt the plane of the arc to an image section plane, that the arc is such so as to exhibit an attenuation of the radiation concerned which is essentially the same or smaller than that exhibited by an organic tissue so that the arc vill form a part of the associated section picture (Figs. 5 and 6), whereby the directions of the apertures (5) are identifiable in order that a suitable path be selected for inserting an examination means (23) through a selected aperture (7).

2. A biopsy arc according to claim 1, characterized in that the apertures (5) have a diameter larger than that of an occurring examination means (23), the respective examination means being adapted to be inserted into a sleeve (21) which can be located in the apertures of the arc.

3. A biopsy arc according to claims 1 or 2, characterized in that one or more groups (7, 9) of the apertures (5) of the arc (1) are radially directed (7) towards a point (8) within the area enclosed by the arc and a second group has a chordal (9) direction, the arc being removably secured (2) to a base member (3, 4) so that it, when

loosened, can be turned and re-secured for adjustment to the proper aperture or group of apertures for the examination under consideration.

4. A biopsy arc according to any of the preceding claims, characterized in that the shanks of the arc (1) can be clamped (2) to slides (10) running along side rails on either side of the base member (4).

5. A biopsy arc according to claim 4, characterized in that a plate (12) is pivotally mounted on the respective slide (10) and cooperating with set means (15, 16) to bring about clamping of the respective shank of the arc between plate and slide.

6. A biopsy arc according to any of the preceding claims, characterized in that the arc is made of a material which has an attenuation with respect to X-ray radiation of 200 H or less.

7. A biopsy arc according to claim 6, characterized in that the arc is made of a material which has an attenuation with respect to X-ray radiation of 80 H.

8. A biopsy arc according to claim 6 or 7, characterized in that the arc is made of polyamide plastics.

9. The use of a biopsy arc according to any of the preceding claims, characterized in that the arc (1) is directed so as to appear in the computed tomographic section concerned (Fig. 5 and 6) in such a way that the radial plane of the apertures, the arc plane, coinci-

des with the plane of the image section, whereupon the or those apertures (7, 9) are selected which have a direction image-wise correct for the examination, so that the necessary penetration depth of the examination means (23) can be determined.

10. The use according to claim 9, characterized in that a computer constructed reference grid is applied to the tomographic picture (Fig. 6) for determining the direction of the examination means (23), selecting aperture therefor and determining penetration depth therof, a centre line (29) being used for marking the target point (8) of the radial apertures (7) in order to proceed from this point towards the arc and select a radial aperture for guiding in an examination means.

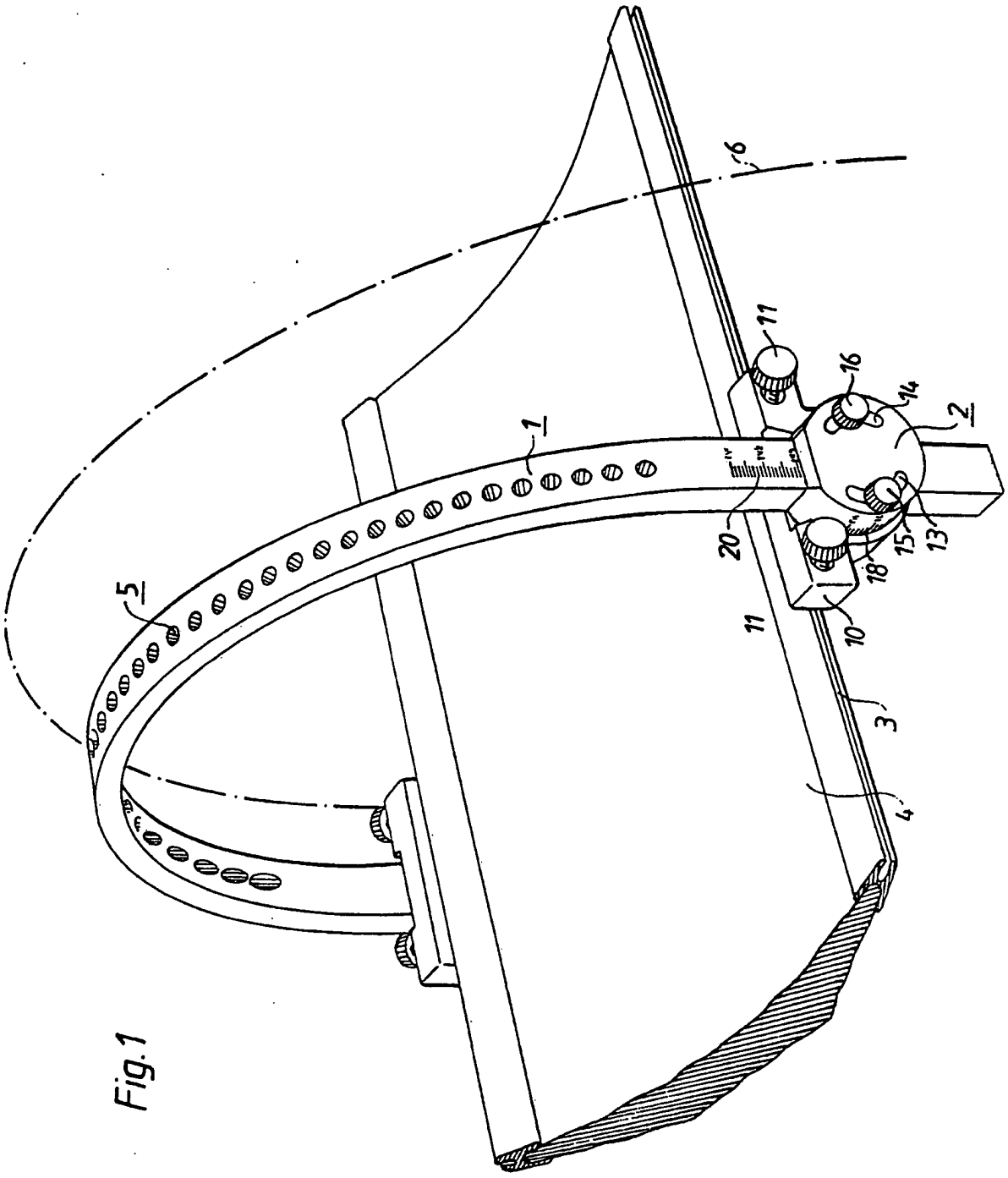


Fig.1

Fig. 2

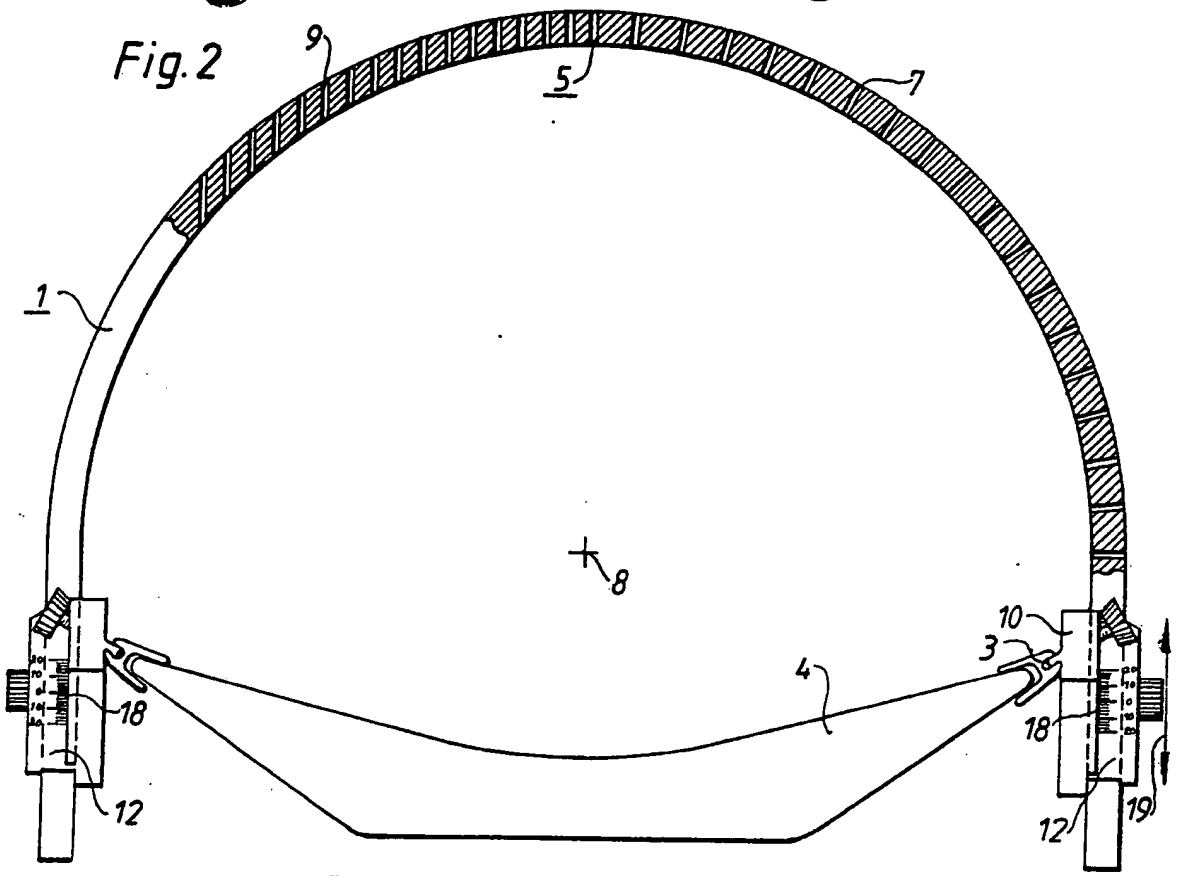


Fig. 3

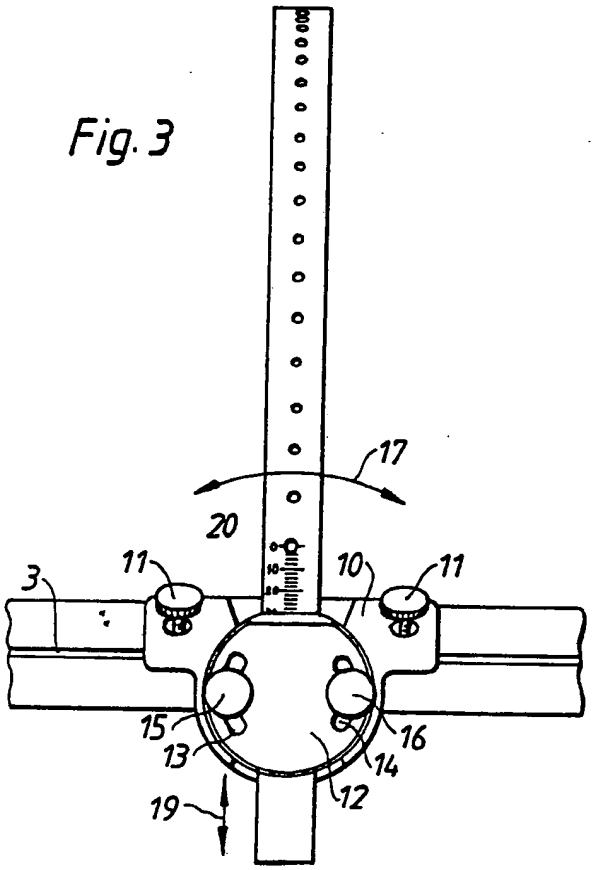


Fig. 4

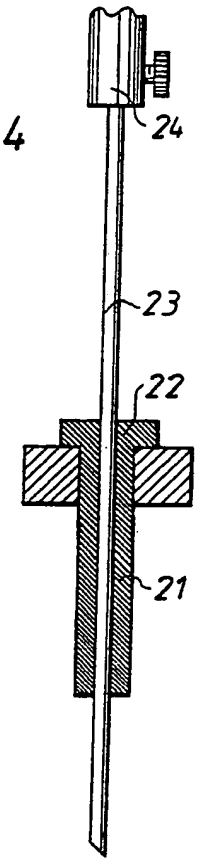


Fig. 5

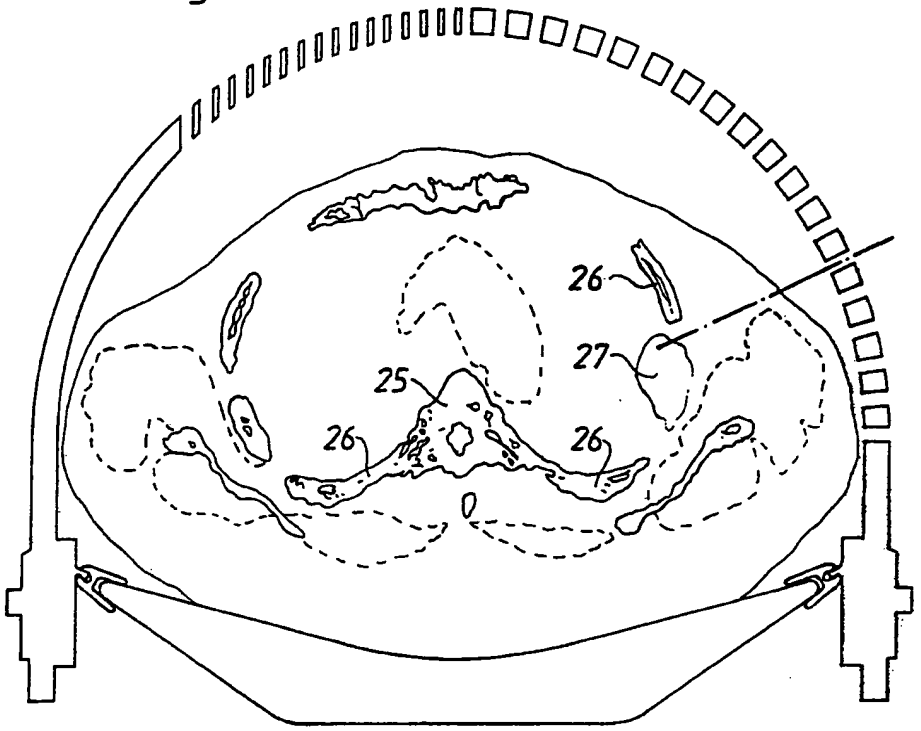


Fig. 6

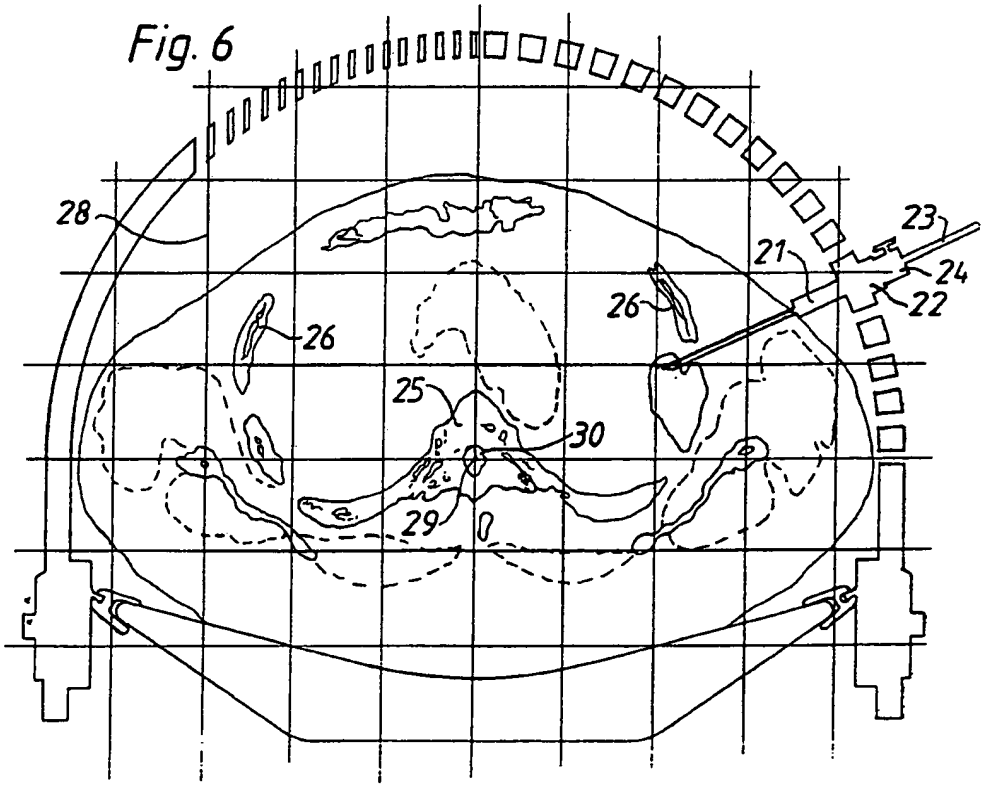


Fig. 7

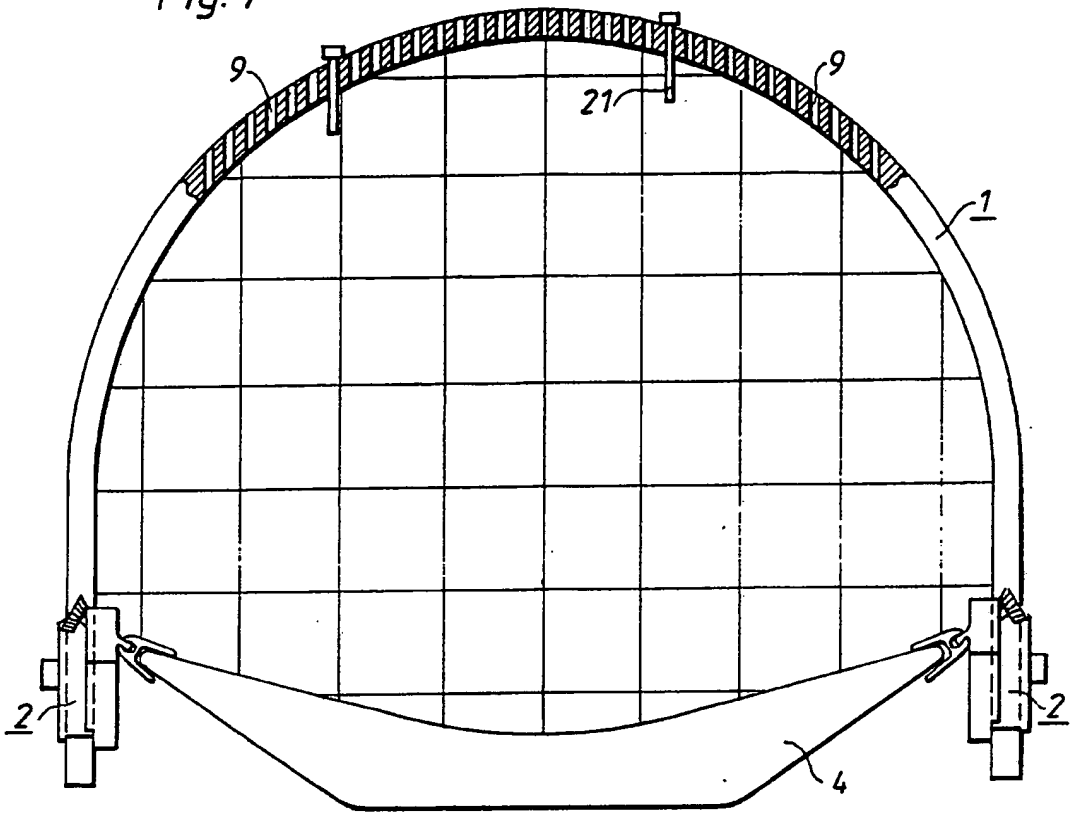
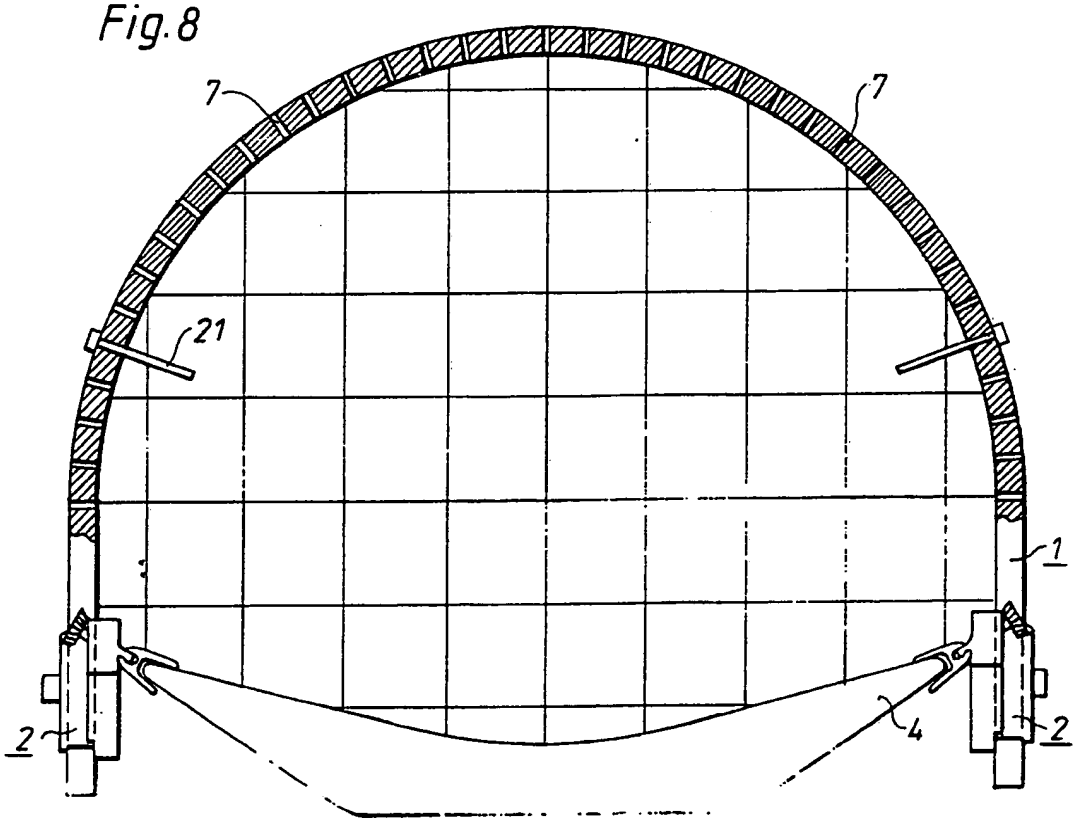


Fig. 8



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE89/00411

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

A 61 B 19/00, 17/34

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	A 61 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4 463 758 (PATIL ET AL) 7 August 1984 See column 4, lines 11-17	
A	DE, C1, 3 339 259 (SCHMIEDING) 14 March 1985	
A	US, A, 4 350 159 (GOUDA) 21 September 1982	

* Special categories of cited documents: [10]
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1989-09-26	1989 -09- 29
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Hans Peterson

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [X] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. [X] Claim numbers 9,10 because they relate to subject matter not required to be searched by this Authority, namely:

Methods for treatment of the human or animal body by surgery or therapy. (PCT, Article 17(2)(a)(i), Rule 39(iv))

2. [ ] Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claim numbers....., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.